



TITLE:

# 総合的な災害リスクマネジメント の方法論としての都市診断技法

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## Urban Diagnosis as a Methodology of Integrated Disaster Risk Management

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### Synopsis

This paper gives an outline of the research outcomes obtained in the fiscal year 2005 by the COE Research Group of Integrated Disaster Risk Management. The primary objective of our entire research activities is to develop and extend a methodology of “urban (regional) diagnosis” for integrated disaster risk management (IDRiM). There are four research focuses, Disaster Risk Management (Disaster risk governance and participatory disaster risk management), Safety control of urban space, Social group conflict analysis, and Social systems for disaster risk reduction and risk sharing. With our related research focuses positioned by a proposed 5-storied pagoda model, their primary results are discussed.

**Keywords:** integrated disaster risk management, urban diagnosis, disaster risk governance, participatory disaster risk management, safety control of urban space and socio and eco risk management, social systems for risk reduction and risk sharing.

### 1. Introduction

Our entire group consists of the following four laboratories which used to come under the Division of Integrated Management for Disaster Risk (IMDR) until the beginning of fiscal year 2005 as a result of DPRI’s reorganization. They are: Disaster Risk Management (focusing on disaster risk governance and participatory disaster risk management), Safety Control of Urban Space (Clarification of Structural Mechanism of Traditional Wood Frames, and Development of Structural Health Monitoring System and Reliability of Uncertain Structures), Water Resources Systems Planning (Social Group Conflict Analysis), and Social Systems for Disaster Risk Reduction and Risk Sharing (Development of a Method to Estimate Economic Losses in Industry, Ambiguity, Risk and Earthquake Insurance Premiums, Flood Risk Communication Support Tool for Making Participant Original Hazard Map ). For us to collaboratively work on the 21 century’s DPRI-COE Research Project, we have developed a methodological framework for integrated disaster risk management, that is called “urban (or regional) diagnosis”. (When we

mean to include rural areas, local communities or area-wide regions, “regional diagnosis” is better used.) In the following the term “urban diagnosis” is used to mean also “regional diagnosis”.

### 2. Urban diagnosis

According to Okada (for instance, 2006) Urban Disaster Diagnosis (UDD) is proposed as a methodology

- to overall assess the spatial risks of urban, regional and community areas under disaster threats.
- to serve as a scientific framework to make a holistic diagnosis of the current status (status-quo) of safety and security of the urban space focused
- to prescribe prospective countermeasures to enhance their quality.

UDD needs to be developed in analogy with physiological risk assessment

UDD also provides us with a methodological framework for developing and positioning a set of tools such as:

- monitoring and measuring techniques
- fragility curves, risk curves

- vulnerability assessment, damage and loss estimation
- economic evaluation of possible alternatives
- prioritizing a bundle of policy issues
- resolving conflicts
- collaborative modeling and partnership formation for shared prescriptions
- a set of information and communication media
- a set of process technology

Though not described here about how specifically it applies to each of our research focuses, the above list gives a comprehensive set of tools, models and information media which come under UDD.

Another useful conceptual construct developed within the framework of UDD is the 5-storied Pagoda Model (Fig. 1).

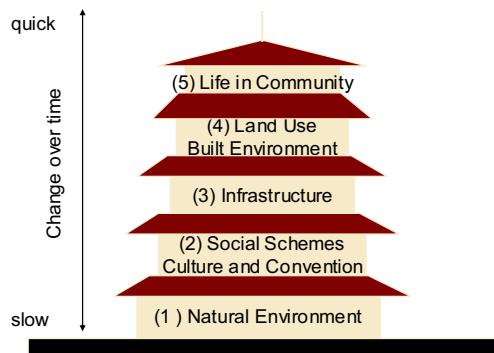


Fig. 1 5-storied pagoda model

This conceptual model offers a useful perspective on the rough positioning of our research focuses as explained later.

### 3. Disaster Risk Management

(N.OKADA and M. YOKOMATSU)

#### Participatory disaster risk management

##### 1) Enhancing community's coping capacity for earthquake risk mitigation (pagoda model: level 1)

This research deals with household earthquake preparedness triggered by indirect disaster experience. A questionnaire survey was conducted to figure out the relevance between the attributes of experiences (distance to the impacted site and hazard type) and types of earthquake countermeasures adopted after indirect

disaster experiences. Using two indicators, i.e., initial and triggered adoption rates, it has been found that 1) disasters occurred in one's neighborhood induce more households' countermeasure adoptions; and that 2) countermeasures with low broad-sense cost are more easily adopted after indirect experience. Local circumstances also make significant difference in people's preparedness before and after indirect disaster experience.

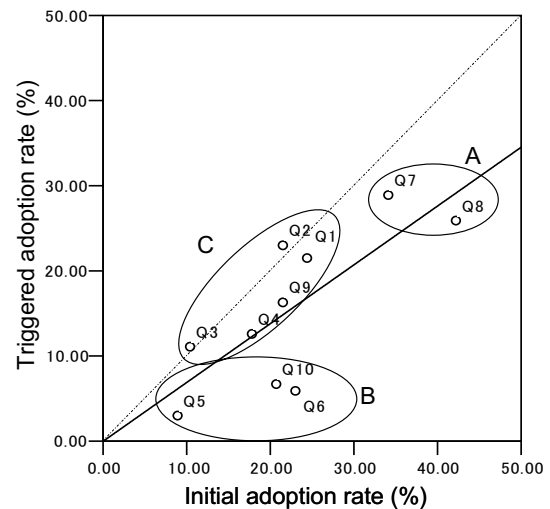


Fig. 2 Scatter chart of initial and triggered adoption rates (source Matsuda and Okada, 2006)

##### 2) Field survey-based systematic formalization of lessons and policy issues on disaster risk communication (pagoda model: level 5)

In this study, based on field surveys the conceptual models are proposed to systematically formalize lessons and policy issues on disaster risk communication. For information flow, from the viewpoint of organizational patterns, hierarchical model and sharing model are proposed to be applied to the command and control situation. For the time flow pattern, the interactive model can be applied to proactive situations. From the relation between information and evacuation behavior, the four-layer conceptual model was proposed as a framework to systematically formalize the process of risk communication in the real world. Also its following policy implications are derived.

#### Disaster risk governance

##### 1) Disaster insurance, public compensation and housing choice (pagoda model: level 2,3,5)

In recent years, several institutional frameworks

were enacted by jurisdictions in Japan, which were intended to provide some type of economic aid (compensation) to the households that are deprived of their dwellings by natural disaster and reconstruct or rent a house in the damaged region. In this paper, a dynamic model is formulated to investigate house-owners and tenants' housing choice after disaster as well as owners' insurance behavior before disaster. The effects of the subsidy system for reconstruction and lease are found such that owners in young generation are motivated to reconstruct houses in the region and tenants in elder generation choose staying in the region over emigration, while owners are discouraged from preparing for disaster with insurance.

## **2) Liquidity risks and demands for earthquake insurances (pagoda model: level 2 and 3 )**

In this research, the three-period incomplete contract model with the liquidity constraint is formulated to investigate why the risk neutral firms are motivated to hold the insurance against the seismic risk. If an earthquake attacks a firm within the period that it does not have prepared the sufficient liquidity for the recovery from seismic loss, the firm is forced to procure the necessary money from the capital market. However, if the firm are endowed with the large amount of debt, it is faced with the difficulty to procure the additional money; i.e., the debt overhang issues. The earthquake insurance is expected to function as the vehicle to overcome the debt overhang issues. The paper also investigates the moral hazard issues caused by holding the earthquake insurance, and presents the Finite insurance schemes to overcome the moral hazard issues and debt overhang issues.

## **4. Safety Control of Urban Space (Y. SUZUKI)**

### **Clarification of Structural Mechanism of Traditional Wood Frames (pagoda model: level 2)**

To make clear the structural mechanism of traditional wood frames to evaluate the seismic performance of wooden buildings like Japanese temples, shaking table tests and static tests using several scale models is described and typical experimental results were carried out. From experiments, it is found that the horizontal restoring force of wooden frame without walls depends mainly on the bending moment resistance from tie beams and the restoring force due to column

rocking. The equilibrium relationship between the total restoring force and all the bending moments involved is established and verified. Using this equilibrium relationship, it is possible to evaluate the restoring force due to column rocking. The restoring force due to column rocking is the major part of the total restoring force when the frame deformation is small. The bending moments from tie beams become dominant as the deformation increases. The traditional wooden frame has the large flexibility and deformability. It is essential to take advantage of the structural mechanisms found from this study in the seismic and enhancement design of traditional wooden buildings.

### **Development of Structural Health Monitoring System and Reliability of Uncertain Structures (pagoda model: level 2)**

Over the past decade, structural health monitoring and management has emerged as a growing and important multidisciplinary field of research with applications in structural engineering. The inherent Uncertainties from both system modeling and measurement noise could greatly affect the performance of a structural health management system, moreover, such assessment is important in seismic reliability and life prediction of the structure. In order to address these important factors, the application of the probabilistic techniques for uncertainty analysis have emerged as an important area in structural health management and reliability evaluation. The Bayesian probabilistic analysis for system identification, Hilbert-Huang transform approach for structural damage detection and stochastic differential equation approach for reliability evaluation are developed.

### **Seismic Performance Evaluation and Seismic Damage Prediction of Traditional Wooden Houses (pagoda level 2)**

To understand and evaluate structural characteristics of typical traditional wood houses “Kyo-machiya” in Kyoto, structural styles and details of thirty traditional wood houses were investigated. The wooden frames, seismic structural elements and joints are clarified. From investigation results, it is found that these wood houses have significantly different base shear coefficients in the directions; in particular, the base shear coefficients in the ridge direction are low. From the seismic performance analyses, it is suggested that the seismic reinforcement is

needed for many traditional wood houses.

In order to promote a seismic reinforcement and to mitigate earthquake damages of wooden houses, it is necessary for inhabitants to recognize the seismic risk of houses. A method for damage prediction of wooden houses based on the results of seismic capacity evaluation and strong motion evaluation is presented. The method is developed so as to simulate the wooden house damage in recent earthquakes in Japan. Finally, we confirmed that the effect of variation of seismic performance on seismic damage mitigation from the results of analysis. The proposed method of earthquake damage prediction can evaluate the seismic performance as probability of damage of wooden house. It is confirmed that wooden houses damage is mitigated in large area by increasing the strength of wooden houses from the analysis results in the case of Hanaore-Fault in Kyoto city. However, in the case of strong ground motions with predominant period in the range of 1 to 3 seconds, damage of wooden houses is not mitigated by increasing the strength of wooden houses. Therefore, it is important to consider not only the strength of wooden houses but also capacity of deformation to mitigate earthquake damage of wooden houses.

## **5. Socio and Eco Risk Management (Y. HAGIHARA)**

### **Social group conflict analysis (pagoda model: level 3,4,5)**

Social conflict between people insisting on environment and people insisting on development comes to be seen frequently. Especially, this tendency is conspicuous in water resources development because its influence is generally widespread. The probability of such conflict should be thought as risk of the project. Management of such conflicts must be considered on any future development project to avoid their intensification and prolongation. A mathematical model is built up to analyze such conflict and to see what kind of equilibrium states could occur. The model mainly consists of two parts. The first one concerns changing process of strategy, which interest parties would choose. The second one sets the model about preference of interest parties, which is needed to set a pay-off matrix in the first part of the model. Furthermore, the model is applied to Nagara River Problem as a case study.

The conflict between people insisting on environment and people insisting on development comes to be seen frequently. Management of such conflict and inducing consensus between them must be considered on a future development project. Without such understanding, appropriate development would not be achieved. People are defined as groups categorized by some features, and assumed to have distribution of opinions. Then, the conflict incidental to development project is modeled as interactive phenomenon of conflict situation and residents' opinion distribution between development and environment. Through the model analysis, it can be seen how the conflict would reach stable states.

## **6. Social systems for risk reduction and risk sharing (H. TATANO and M. HATAYAMA)**

### **Development of a method to estimate economic losses in industry (pagoda model: level 3,4)**

As to avoid double counting economic losses, it is shown important to distinguish the effects between disaster and recovery [Tatano, et.al.,2000, Tatano, 2006]. When we estimate total economic loss which includes foregone revenue in industries, these two effects should be estimated in the consistent way. When we estimate total economic loss, the loss caused by the disaster and net present value of recovery actions should be summed up. According to Tatano, et.al. (2000), the total economic losses of a firm equals to "foregone revenue" plus "recovery cost. This means that it is consistent with the conventional loss estimation framework which defines total economic loss of a firm as sum of direct and indirect losses if the direct loss is estimated as "recovery cost of the damaged assets" and the indirect loss are defined as "foregone revenue". The further research is conducted in this year to find the consistent way for aggregation of the economic losses in an economy. For this purpose, economic losses of a firm is reconsidered and it is found that difference of the net cash flows between the scenarios with and without a disaster is also the consistent measure of the total economic loss of a firm. A method to conduct consistent aggregation of economic losses over an economy is investigated. The method request us to sum up all the difference of the cash flows over industries in the economy and calculate the net present value of them. The net present value is shown to be coincident with the foregone revenue of the

damaged firms and resource expenditures of firms which provide recovery services, which are the real opportunity cost of the economy. A case study was also conducted to apply the methodology for estimation of total industrial losses in the Niigata Chuetsu Earthquake.

#### **Ambiguity, Risk and Earthquake Insurance Premiums: An Empirical Analysis (pagoda model: level 5)**

In this study, I empirically investigate the influence of the ambiguity of insurance payment on the consumer's decision to purchase an earthquake insurance by applying an econometric model to questionnaire data. Then, I examine the relationship between the ambiguity effect and individual characteristics.

Individual disaster-prevention efforts play important roles to mitigate the damage and to promote the emergency restoration. As for earthquake, the earthquake insurance can be helpful to repair or rebuild damaged houses. However, purchase rate of earthquake insurance is low in Japan (only 17.2% households buy the earthquake insurance). One of the most important reasons is ambiguity of insurance payment. It means the lack of knowledge on the earthquake insurance policy and insurance adjustment.

Ambiguity of insurance payment stems from unclear criteria that the insurance adjuster will use to assess the damage from earthquake. This makes consumers feel concerned over the possibility that the claim is not paid as they expect. In this case, they think of earthquake insurance as "probabilistic insurance" introduced by Kahneman and Tversky (1979). Probabilistic insurance is an insurance policy which, in the event that the hazard occurs, pay off with some probability strictly less than one.

In the classical economic analysis, insurance is explained by concavity of utility. In MEU theory, insurance is explained by ambiguity aversion. The observed aversion to probabilistic insurance suggests that the purchase of insurance is driven primarily by the robust-prone to ambiguity rather than by diminishing marginal utility. Although this paper dealt with the earthquake insurance, there are many other decision problems in which one perceives the ambiguity for the outcome from the investment to reduce the probability of some hazard, such as earthquake retrofit and fire-proofing of a house. Our result suggests that

guarantee of their performance or complete recompense in case of failing may dramatically increase their value.

#### **Flood Risk Communication Support Tool for Making Participant Original Hazard Map (pagoda model: level 4,5)**

To realize safe autonomous evacuation, citizens should obtain well developed "mental model" for evacuation which includes appropriate perception mechanism to preserve flood risk and flexible "alternative set" for evacuation actions. Aiming at constructing well developed mental models which citizens' evacuation actions are determined based on, the paper develops a flood risk communication support system. Through communication among stakeholders assisted by the system, changes in flood risk perception and increase in the flexibility of the alternative plans of evacuation actions are observed in the experimental workshops in Kiyosu City, Aichi prefecture.

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## 総合的な災害リスクマネジメントの方法論としての都市診断技法

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### 要 旨

本研究は、京都大学防災研究所21世紀 COE研究プロジェクトの一環で旧総合防災研究グループが2005年度に行った研究成果の概要をとりとめたものである。本研究活動全体の主たる目的は総合的な災害リスクマネジメントのための方法論として、都市診断技法を開発し、発展させることである。すなわち、災害リスクマネジメント(災害リスクガバナンス、参加型災害リスクマネジメント)、都市空間の安全制御、地域水環境システム、防災社会システムの4つの研究課題を取り上げた。五層モデルを用いて各研究の位置づけを示すとともに、それぞれの研究成果について概説した。

**キーワード:** 総合的な災害リスクマネジメント, 都市診断, 災害リスクガバナンス, 参加型災害リスクマネジメント, 都市空間の安全制御, 社会・生態環境研究, 防災社会システム